FEEDING PREFERENCE OF *PRODENIA* SPECIES ON SWEETPOTATO VARIETIES

By

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INTRODUCTION

Five species of *Prodenia* occur commonly throughout Florida. They are *eridania*, *ornithogalli*, *dolichos*, *latifascia*, and *sunia*. *P. dolichos*, *eridania*, and *ornithogalli* attack sweetpotato; especially the first two. These are the only important foliage feeders on sweetpotato in Florida. They are common throughout Florida except for *P. sunia* which is restricted to the southern half of the state.

Information on the resistance of sweetpotato to insects is almost entirely limited to soil insects attacking the roots. Recently, it was shown that *P. eridania* did not feed to the same extent on all sweetpotato varieties (Habeck, unpublished data). This investigation was initiated to determine whether preference for certain sweetpotato lines and varieties existed among the *Prodenia* larvae and to determine whether any of the lines or varieties affected development. The results of this work may serve either as a guideline in a program for breeding sweetpotato varieties resistant to attack by *Prodenia* species or as a possible method of control.

LITERATURE REVIEW

Six species of Prodenia occur in Florida (Kimball 1965). They are eridania (Cramer), ornithogalli Guenee, dolichos (Fabricius), latifascia Walker, sunia (Guenee), and pulchella (Herrich-Schaeffer). The last-named species has been collected in Florida only a few times and may not be established. The other 5 species occur commonly throughout the state except for sunia which is limited to the southern half of peninsular Florida. The available biological information on the 5 species used in this investigation is summarized below.

Prodenia ornithogalli Guenee, 1852

The yellow-striped armyworm, P. ornithogalli is common throughout Florida, probably the year round. The females of this and P. latifascia are easily confused (Kimball, 1965).

Crumb (1929) stated that this species was common only in the South although it occurred north to Massachusetts, west to Minnesota, Nebraska, New Mexico, Arizona, and California and also in the Bahama Islands, Puerto Rico, and Mexico. Van den Bosch & Smith (1955) reported that P. ornithogalli was a tropical species with no true winter diapause and that it occurred throughout South and Central America, and the Caribbean. The most complete list of host plants for this polyphagous species is given by Crumb (1929) who lists the following plants: Amaranthus retroflexus, A. spinosus, asparagus, aster, bean, beet, cabbage, castor bean, clover, corn, cosmos, cotton, cottonwood, cucumber, Erigeron

canadensis, grass, jimson weed, moon vine, morning glory, Nicandra physalodes, onion, pea, peach, petunia, Plantago lanceolata, pokeberry, potato, rape, raspberry, rhubarb, Rumex, rutabaga, salsify, Sida spinosa, Solanum carolinense, soybean, sweetpotato, tobacco, tomato, turnip, violet, watermelon, wheat, and wild onion. In the Virgin Islands, it fed on cotton, grasses, most truck crops, and physic-nut (Jatropha gossypiifolia)(Wilson, 1923). Poveda and Schwitzer (1964) found that Amaranthus dubius Mart. and Portulaca oleracea L. were the common host plants in cotton growing areas.

They reported that P. ornithogalli sometimes occurred as an important pest of cotton and caused losses from the time the seed germinated until the crop was ready for harvest. Watson and Tissot (1942) found that P. ornithogalli attacked sweetpotato particularly during July and August in Florida. They fed during the daytime and could defoliate an entire field if not controlled. Crumb (1929) reported that first and second instar larvae skeletonized the leaves of clover and probably other plants in the tobacco field until larvae reached the third instar when they were able to survive on tobacco. Larvae usually hid beneath debris on the ground or on the underside of leaves. Sometimes larvae were found boring into tomatoes and cotton bolls. The eggs were deposited in a mass but usually only 1-2 larvae occurred in one place because after hatching they spun down and were dispersed by the wind. In the Mississippi delta it was a pest of cotton and many other crops (Lowry and Calhoun, 1952). It wintered in the pupal stage in the soil and had several generations a year.

Detailed descriptions of adult, egg, larva (including 6 instars), and pupa were given by Crumb (1929). Eggs are deposited in masses on

the foliage of plants and trees, on buildings and other outdoor environments (Lowry and Calhoun, 1952). The egg masses are covered with scales from the body of the female moth. After hatching, larvae migrate to nearby vegetation and become voracious feeders.

Prodenia eridania (Cramer), 1782

The southern armyworm, P. eridania is quite common throughout Florida (Kimball, 1965).

Crumb (1929) and Chittenden and Russell (1909) reported that this species occurs in the Southeastern United States and also in the West Indies, Central and South America.

Food plants as quoted from Crumb (1929) are "Amaranthus spinosus L., avocado, beet, blood root, cabbage, carrot, castor bean, citrus trees, clover, collard, cotton, cowpea, crab grass, eggplant, okra, oleander, peanut, pepper, pokeweed, potato, Rumex, Solanum, sunflower, Sonchus, sweetpotato, velvet bean, tobacco, tomato, watermelon, and willow." Chittenden and Russell (1909) and Berger (1920) listed the same host plants as Crumb (1929) including beggarweed, careless-weed (Amaranthus sp.), poke-weed, morning-glory, and Sonchus sp.

P. eridania was satisfactorily reared in the laboratory on beans, tomato, sugar beet, sweetpotato, prickly lettuce, Lactuca scariola L., dandelion, Taraxacum officinale Weber, pokeweed, Phytolacca americana L., redroot pigweed, Amaranthus retroflexus L., common lambsquarters, Chenopodium album L., kale, and spinach, as well as plants of the families Polygonaceae and Convolvulaceae (Soo Hoo and Fraenkel, 1964).

In the study of the consumption, digestion, and utilization of 18 different plants representing 13 families by P. eridania, 10 different

plants were very efficiently converted to body matter (Soo Hoo and Fraenkel, 1966b). Of 74 species belonging to 64 genera and 32 families, used in an acceptence and growth survey, 41 supported growth to a greater or lesser degree (Soo Hoo and Fraenkel, 1966a).

Larvae are gregarious when they are young, dispersing when approaching maturity unless they occur in great numbers, when they may travel in compact bodies similar to the armyworm (Crumb, 1929). In an outbreak at Orlando, Florida, Chittenden and Russell (1909) estimated that on 10 plants of Amaranthus spinosus 6 feet high there were 1,300 larvae. They fed freely in the daytime, not only stripping plants of their foliage but also consuming the tips of the branches, the pith in the stems, and even potato tubers in the soil. Berger (1920) observed, in a general outbreak in Florida, in 1918, that, when attacking castor beans, the larvae, after consuming the leaves, ate the petioles and the tips of the branches. The larvae congregating about the base of the plant in the daytime were also observed to consume the bark near the base. About 200 to 400 large larvae were frequently found on a single castor-bean leaf in badly infested areas and 30 to 50 pupae were found per square foot of soil. Patches of careless weed (Amaranthus spinosus) and pokeweed (Phytolacca decandra) were found to be centers of infestation. Life cycle is about 35 days. Four and possibly 5 generations occur annually.

P. eridania is one of the most destructive pests on truck crops in Florida. It feeds on a great variety of plants. Quite often it appears in large numbers on vegetable crops before harvest, causing a definite loss unless controlled by artificial means (Wisecup and Reed, 1938). It attacked sweetpotato particularly during July and August (Watson and

Tissot, 1942). Larvae usually appear first in spots in the field and if not checked, they spread from these spots to the whole field, travelling like armyworms. Although the defoliated vines may put out new leaves and continue to grow, the yield of roots is always greatly reduced, and may be entirely destroyed as a result of the attack (Watson, 1919).

In the summer of 1928 an outbreak of this insect occurred in the Everglades where they defoliated water hemp (*Acnida cannabina* L.) and were found on many grasses, cowpeas, etc. Later they appeared over the entire peninsula as far north as Gainesville, where they attacked sweet-potatoes, many grasses, and especially coffeeweed (*Glottidium vesicarium* (Jacq.) Desv.). When citrus growers cut cowpea cover crops this insect attacked and damaged young citrus trees (Anonymous, 1928a). Later, the worms were very abundant on snap beans where they preferred the young pods rather than the leaves (Anonymous, 1928b).

Chittenden and Russell (1909) reported that duration of the egg stage was 4-6 days, larval stage was 17 days, and pupal stage was 9-13 days or 31-36 days for the life cycle. There were 4-5 generations a year.

In 1928 throughout the coastal sections of the Carolinas, *P. eridania* larvae were carried into the curing houses during harvest where they damaged the sweetpotatoes during the warm curing period temperatures. Larvae fed on potatoes, tunnelling completely in, making numerous holes and in some cases consuming the entire potato except for the outer covering (Thomas, 1929).

A detailed description of the adult, egg, larva, and pupa were given in Crumb, 1929.

Prodenia dolichos (Fabricius), 1794

P. dolichos is quite common throughout Florida. It is also a general feeder (Kimball, 1965).

Crumb (1929) reported that this species occurred from Massachusetts to Florida and west to Illinois, Kansas, and Texas.

Quaintance (1898) stated that P. dolichos feeds on crab grass, wild coffee, partridge pea, tomatoes, okra, and tobacco in Florida. Crumb (1929) listed food plants including tobacco, Physalis, Nicandra physodes, tomato, turnip, jimson weed, asparagus, violet, Commelina communis, ground pea, sweetpotato, cotton, raspberry, and grass. The larvae often feed exposed upon plants in the daytime.

Crumb (1929) described adult, egg, larval, and pupal stages in detail. Duration of the egg stage was 4-8 days, the larval stage was 23 days and the pupal stage lasted 14-18 days.

P. dolichos caused considerable damage in Florida to tomatoes, Irish potato, and sweetpotato. The young larvae were found on the lower surface of the leaves, more or less congregated, frequently as many as 25 or 30 on a single leaf. Small holes were eaten from the lower surface to the epidermis of the upper surface of the leaf, while the larger larvae were found all over the plants. When larvae infested sweetpotato vines they caused considerable damage to the sweetpotato crop throughout the field. After consuming the foliage, the larvae migrated to surrounding fields (Quaintance, 1897, 1898).

P. dolichos appeared in great numbers in an experimental tomato field in Bradenton, Florida. Previous to this only solitary larvae were observed rather than large colonies (Kelsheimer, 1950).

Prodenia latifascia Walker, 1856

P. latifascia was unknown in Florida until Mason (1922) found it feeding on young leaves of a grapefruit tree at Orlando. It is of no economic importance as a citrus pest. It was reared from Plumbago capensis (Kimball, 1965). Wilson (1923) reported it as a cotton pest in the Virgin Islands. It is a tropical insect found from Mexico to Argentina including the West Indies and it was reported breeding on onions and alfalfa in Texas. It is common throughout Florida (Mason, 1922).

The average duration of the larval and pupal stages of this species at 27°C was 14.7 and 9.9 days, respectively (Habeck, unpublished data).

Prodenia sunia (Guenee), 1852

P. sunia is apparently a fairly recent introduction into Florida or at least was not recognized until recently. It has been found only in south Florida with the most northern record being from Bradenton (Kimball, 1965).

Cotton (1918) reported that P. sunia was a general feeder, particularly abundant on chard in Puerto Rico. Poveda and Schwitzer (1964) stated that this species and P. ornithogalli sometimes infested cotton and caused losses from seed germination until the crop was ready for harvest. Amaranthus dubius Mart. and Portulaca oleracea L. were the common host plants in cotton zones. In the Virgin Islands, it fed on castor bean, beet, and chard, and was considered to be an occasional pest of cotton (Wilson, 1923).

According to Wilson (1923), the eggs are laid in clusters of 200 to 300 on the underside of leaves. The eggs hatched in 4 to 8 days, the

larval stage lasted 12-20 days and the pupal stage 10-12 days. In Florida, the larval and pupal stages together required 24-36 (average 27.5) days at 27°C and 33-47 (average 37.6) days at 22°C (Habeck, unpublished data). It has been reared on Amaranthus sp. by Nakahara, (Kimball, 1965) and Portulaca oleracea by Habeck, and collected from cabbage by Wolfenbarger, onions by Kelsheimer and Sesbania by Habeck (Habeck, unpublished data). No other food plant records are available from Florida for this species.

Resistance to Insects in Sweetpotato

Cockerham and Deen (1947) in Louisiana suggested that there is a possibility of breeding sweetpotatoes resistant to the sweetpotato weevil, Cylas formicarius elegantulus (Summers). They examined 4 seedlings and varieties in 1941 and Unit #1 Porto Rico had fewer weevils in stems and roots, while L4-5 had significantly more weevil infested roots than the others. Large, soft stems or crowns were favorable to attack. No direct relation between crown infestation and potato infestation occurred. Potatoes formed away from the crown appeared to be less susceptible to weevil attack. Over a 6-year period (1941-6), seedlings least infested were high in moisture and carotene and low in starch content and conversely, seedlings heavily infested were low in moisture and carotene and high in starch.

In an experiment in Hawaii on sweetpotato seedling improvements, Porto Rico and Onolena were significantly more susceptible to weevil attack than HSPA 3 and HES 45 (Poole, 1952). In another experiment, Onolena was found to be more susceptible to weevil attack than Porto Rico and HES 8. Porto Rico was susceptible to attack of the sweetpotato

vine borer, Omphisia anastomosalis (Guenee). HES 8 was also fairly resistant to weevils as well as to cold weather and to soil-inhabiting root rot organisms.

Many Jersey varieties proved to be highly susceptible to the sweet-potato weevil during an epidemic at Mayaguez, Puerto Rico (Anonymous, 1951). In the Philippines, the variety Segurada was found to be very susceptible to Cylas formicarius (Calma and Paningbatan, 1951). The seedlings L 185 (32-10-5) and L 244 showed a high degree of resistance to Cylas formicarius elegantulus in tests in Louisiana (Cockerham and Harrison, 1952). Thick-skinned sweetpotato roots were resistant to Cylas formicarius (Loebis, 1955). Five selections from local varieties of sweetpotato collected from Mysore States, India, possessed some resistance to the weevil, Cylas formicarius (Krishna, 1959).

Field and laboratory studies were made in 1964 in Louisiana to evaluate seedlings and varieties for banded cucumber beetle, Diabrotica balteata LeConte resistance. Seedlings L3-64 and L4-89 showed a considerable degree of resistance, with L3-64 being the most resistant (Anonymous, 1964).

In a field plot comparison of 48 varieties, in Charleston, S.C., injury by all species of root damaging larvae ranged from 21.1% for Louisiana 3-64 to 87.1% for Louisiana 0-55, 1-193, and 0-156. All of the commercial varieties included had more than 50.1% of their roots injured, and three varieties (Centennial, Gold Rush, and Carogols) had more than 70.1%. Laboratory tests indicated the presence of 2 separate resistance factors, 1 located in the skin, the other in the flesh; varieties that were rated as resistant in the field plots had both (Cuthbert, 1965).

Habeck (unpublished data) evaluated the injury caused by a natural infestation of P. eridania larvae during the fall of 1966 in sweetpotato variety trial plots located at the Horticultural Unit, University of Florida. One variety, North Carolina Porto Rico 198 had considerably less injury than any of the other varieties and Gold Rush was most severely injured. The differences obtained indicated some varietal difference which affected feeding by Prodenia larvae.

Painter (1958, 1968) and Beck (1965) reviewed the general aspects of resistance of plants to insects. They covered such topics as: a thorough analysis of the relationship between plants and phytophagous insects, the mechanisms underlying resistance phenomena, together with a full examination of insect resistant varieties of major crops and an extensive review of publications on the phase of resistance.

MATERIALS AND METHODS

Rearing and Testing Room

Rearing and testing were done in a laboratory equipped with white fluorescent lamps which provided approximately 300 foot-candles of light. A 14:10-hr light:dark period was maintained with the lights on from 8:00 a.m. to 10:00 p.m. Temperature was maintained at $76 \pm 2^{\circ}F$ by a reverse-cycle air conditioner. The humidity was not controlled.

Diet Preparation

A slightly modified Shorey and Hale (1965) pinto bean medium (Table 1) was utilized for rearing the *Prodenia* larvae. Dry pinto beans were soaked overnight and blended and the diet ingredients, with the exception of the agar, were added and blended with 1/2 the total amount of water. The agar was boiled in the remaining water at $100^{\circ}C$. To minimize exposure of labile compounds to high temperature, the agar solution was allowed to cool to about $70^{\circ}C$ before it was blended with the other ingredients.

The medium was poured into 1 oz clear plastic cups (No 601 0, Premium Plastic, Inc., Chicago, Ill.). The cups were filled 1/2 to 3/4 full, allowed to cool 15 to 30 minutes, and then capped with cardboard lids (Smith-Lee Co., Inc., Oneida, N.Y.). Cups containing the diet were refrigerated until needed. The air exchange in the cups was sufficient to allow adequate larval respiration during their development.

Table 1. Composition of an artificial medium used for rearing *Prodenia* species (modification of Shorey and Hale's medium)

Ingredients	0.3 quantity of original medium	Modification
Soaked pinto beans	639.9 g	640.0 g
Dried brewers' yeast*	96.0 g	100.0 g
Ascorbic acid*	9.6 g	10.0 g
Methyl para-hydroxybenzoate	6.0 g	6.0 g
Sorbic acid*	3.0 g	3.0 g
Formaldehyde 40%	6.0 cc	6.0 cc
Agar	38.4 g	40.0 g
Water	1,920.0 cc	1,920.0 cc

* Nutritional Biochemicals Corporation, Cleveland, Ohio

Mass Rearing

In 1967, 4 species of *Prodenia* were reared: *eridania*, *latifascia*, *ornithogalli*, and *sunia*. Four species of *Prodenia* reared in 1968 were *eridania*, *ornithogalli*, *sunia*, and *dolichos*.

Most of the larvae used in the tests were from laboratory colonies raised on a slightly modified Shorey and Hale pinto bean medium. Eggs were collected from light-trapped females caged in plastic bags. Egg masses deposited on the plastic were removed by cutting the plastic around the mass. The eggs were placed in petri dishes containing moist paper towels. The dishes were covered with Alcoa film[R] to maintain moisture and to prevent larval escape.

Approximately 20 newly hatched larvae were placed into each medium cup. When they became second instar larvae, they were transferred into 1/2 pint cartons with moist paper towel fitted in the bottom. Petri dish bottoms were used as lids. The medium cups were broken to expose more diet surface for larval feeding and placed in the carton. The cartons were examined and new medium was added as needed. Frass was removed from the cartons as it accumulated and the towel was replaced when soiled. As the larvae increased in size, the number of larvae per carton was reduced leaving about 10 larvae per carton by the time they had reached the fourth instar. At least once during rearing larvae were transferred into new cartons.

The larvae were checked daily and prepupae, when found, were placed on a piece of moist towel in another carton. Ten to 15 prepupae were held in a single carton until pupation took place. Cartons of prepupae were examined daily for pupae and moisture was added as needed. Pupae were collected, divided by sex, and transferred into another carton

lined with moist towels. Just before adult emergence, 5 male and 5 female pupae were placed in a 1 gal cylindrical cardboard breeding carton with single layer cheese cloth tops (Fig. 1). Malformed and diseased pupae were discarded. Only apparent healthy pupae were placed in the carton.

Pupae in the breeding cartons were moistened and examined daily for adult emergence. Ten percent sucrose solution was placed in a 1 oz plastic cup containing Cellucotton®. It was fastened by masking tape to the inside wall of the breeding carton. Most eggs were deposited on the cheese cloth which was replaced daily. The cheese cloth was cut to remove the egg masses which were placed into petri dishes containing moist paper towels. Newly hatched larvae were placed into cups with diet and the cycle was repeated.

Sweetpotato Lines and Varieties

In 1967, 12 sweetpotato varieties (supplied by Dr. V. F. Nettles, Vegetable Crops Department, University of Florida) were grown for test purposes. The varieties and lines tested were as follows:

1. Julian	7. Rose Centennial
2. Gem	8. NC 172
3. Centennial	9. Unit #1 Porto Rico
4. Gold Rush	10. Georgia Red
5. PR 198	11. NC 212
6. LO-246	12. Cuban

In 1968, 24 sweetpotato lines and varieties (supplied by Dr. S. A. Harmon, Department of Horticulture, Georgia Agricultural Experiment Station, Tifton, Georgia) were grown for test purposes. The sweetpotato

Figure 1. One gallon cardboard cartons used to hold adult moths for mating and oviposition

lines and varieties representing diverse genetic make-up were selected by Dr. Harmon from hundreds of breeding lines. The following breeding lines and varieties were tested:

1. 66-38x23-2
2. 64-Gx-102-1
3. 65-ES-S3
4. 65-2op-8
5. 65-72xG-1
6. NC-246
7. 63-T-3xE-3
8. 61-15op-35
9. 63-ExG-8
10. 64-2x23-71
11. Johnson
12. 66-T5x23-1
13. 66-23op-3
14. Georgia Red
15. 66-Gop-7
16. 61-15op-41
17. Hayman
18. 66-26op-5
19. Coastal Sweet
20. 65-2x63-1
21. Muguga
22. 308198
23. 64-10op-4
24. 0-T6x16op-13

These varieties and breeding lines were grown at the Department of Entomology and Nematology Honey Plant area. Each plot consisted of a single row. In 1967, the varieties were grown in a complete randomized block design with 4 replicates. The plots in 1968 were not replicated.

Testing Procedure

Preference test

An attempt was made to determine whether first instar larvae of *Prodenia dolichos*, *eridania*, *ornithogalli*, and *sunia* preferred one variety over another. Twenty-four varieties and breeding lines were tested for this response in 1968. Undamaged sweetpotato leaves were collected from the field as described above. Leaves were cut into

quarter circles and placed onto moist Whatman® no. 1 filter paper. The adjacently placed leaf sections now formed a circle equal in area to and coinciding with the piece of filter paper (Fig. 2 and 4).

A partially incomplete block design (Group Divisible Design) proposed by Bose et al. (1954) was utilized. The moist filter paper under each leaf section was marked, indicating the number to which lines and varieties were randomly assigned (Fig. 3), and placed into petri dishes. Ten first instar larvae were placed at the center of the dish. The dish was covered with Alcoa film® to prevent larval escape and to maintain moisture within the dish.

After 48 hours, the leaves and the larvae present on them were removed and placed in a solution of formaldehyde and alcohol (Fig. 5) (Ainsworth, 1961). The number of leaf units (0.01 sq in) of each sweetpotato variety consumed by the larvae was determined later by placing each leaf over graph paper.

Physical and chemical leaf component test

To investigate whether feeding was due to the physical properties of the leaf, 10 larvae of first instar P. ornithogalli (48 hours old) were placed one at a time on the underside of either the most susceptible or the most resistant line or variety as determined by the preference test. The larvae were observed under the microscope for 5 minutes to determine the number which fed on each line or variety. To determine whether feeding was due to physical or chemical properties, leaves of the most susceptible and the most resistant line or variety as determined by the preference test were blended for 3 minutes and incorporated in 2% agar. A total of 200 cc of water per 50 g of leaves was used. The

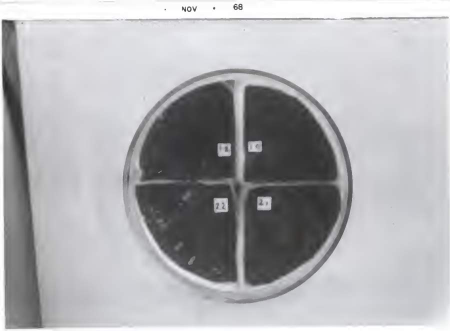

Figure 2. Petri dishes with sweetpotato leaf quarter-circles on moist filter paper after 48 hours exposure to 10 Prodenia dolichos (F.) larvae

Figure 3. Petri dish showing marked filter paper after removal of leaf circles after 48 hours

Figure 4. A quarter-circle sweetpotato leaf after 48 hours exposure to Prodenia dolichos (F.) larvae

Figure 5. Vials with preservative holding sweetpotato leaf sections and larvae after conclusion of preference test

solidified agar leaf media and water agar media were cut into 1/2 inch disks with a cork borer. Four disks were placed into each petri dish; 2 water agar disks (check) and either 2 resistant or 2 susceptible agar disks. The dishes were covered with Alcoa film®. This process was replicated 4 times making a total of 8 petri dishes. Ten first instar larvae were placed in the center of each dish and the number of larvae present on the agar disks was determined after 1, 3, 6, and 12 hours. This test was repeated to determine whether feeding was due to preference after the physical properties of leaves were eliminated by the blending process. The procedure was exactly as above except that each dish contained 2 water agar disks (check), 1 resistant, and 1 susceptible agar disk. This test was replicated 4 times making a total of 4 petri dishes.

A search for nature of feeding stimulant was undertaken. Cold water, hot water, and chloroform + methanol (2:1) leaf extracts were made. Thirty grams of leaves of the most susceptible and the most resistant lines or varieties were separately blended in 80 cc of cold water, boiling water, and chloroform + methanol (2:1) for 3 minutes. Each extract was then filtered through Whatman® no. 1 filter paper until each filtrate had been obtained. Six cc of extracts from cold and hot water were incorporated into 15 cc of 2% agar solution.

The solidified agar leaf extract media and water agar media (check) were cut into 1/2 inch disks with a cork borer. Two-tenths cc of the chloroform + methanol extract was applied topically to a water agar disk and the solvent allowed to evaporate. One dish contained water, susceptible and resistant leaf extract in agar disks for each extract, making a total of 9 combinations. There were 6 replicates. Agar disks were placed on 1/3 cut circles of filter paper (Figure 6). Ten first instar

Figure 6. Petri dish, filter paper set-up used to test larval preference for agar disks containing resistant or susceptible leaf extracts or plain water. Extracts were obtained with chloroform + methanol, hot water, and cold water (left to right)

larvae were placed in the center of each dish. The dishes were covered with Alcoa film®. The relative acceptability of different extracts to the larvae was evaluated by counting the number of larvae present on the disks at the end of 1, 3, 6, and 12 hours.

Antibiosis Test

Twelve varieties of sweetpotatoes were checked in 1967 to determine whether any difference in suitability for larval development existed. The *Prodenia* species tested were *eridania*, *latifascia*, *ornithogalli* and *sunia*. In 1968, 24 varieties and breeding lines were tested for possible effects on larval development of *P. dolichos*, *eridania*, *ornithogalli*, and *sunia*. Evaluation was based on (1) percent pupation, (2) duration of larval-pupal stages, and (3) pupal weight.

Sweetpotato leaves were randomly collected from the field plots after checking to make certain the vine selected was from the proper row and not from an adjoining row. Not more than 10 leaves were taken from any one vine and none of the last 4 developing leaves were ever taken. The leaves were placed in plastic bags with labels and taken to the laboratory. All but 2 inches of the petiole was cut from each leaf and this was wrapped in Cellucotton® near the leaf base and inserted into a water-filled 9 dm vial to keep the leaves fresh. Vials with leaves were placed into 1/2 pint cardboard cartons. Five first instar larvae were placed on the leaves in each carton. Petri dish bottoms were placed over the cartons and fastened with rubber bands to prevent escape of the larvae (Fig. 7).

Leaves were replaced daily or as necessary throughout the test to keep a fresh and constant food supply for larval feeding. The test was

Figure 7. One-half pint cardboard carton rearing cages showing vials with sweetpotato leaves

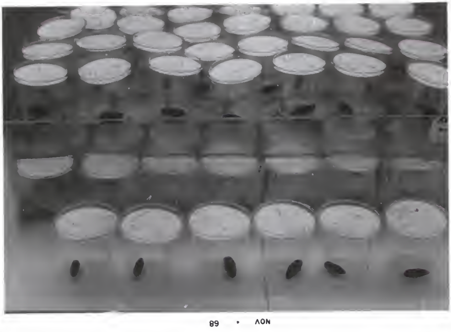

Figure 8. Large plastic box with 1 oz plastic cups used to hold individual pupae

replicated 4 times. All larvae were kept in the cartons until pupation. Frass was removed from the cartons as it accumulated. Pupae were collected and individually placed into 1 oz plastic cups with lids which were kept in a plastic shoe box containing 2 layers of moist paper towel (Fig. 8).

RESULTS AND DISCUSSION

Preference Test

Twenty-four lines and varieties of sweetpotato were tested in 1968 to determine whether first instar larvae of Prodenia eridania, ornithogalli, sunia, and dolichos would prefer one variety over another. The evaluation for preference was based on the number of leaf units consumed by each species of Prodenia first instar larvae in 48 hours. The results are presented in Tables 2, 3, 4, and 5. The average number of leaf units consumed and the range for the 7 replicates is given, as well as the adjusted mean obtained by statistical analysis. The lines and varieties are arranged from low to high according to the adjusted means.

Significant differences in preference were obtained for P. eridania and ornithogalli (Tables 2 and 3) but not for P. sunia and dolichos (Tables 4 and 5).

The greatest differences in the average number of leaf units consumed was obtained with P. eridania (Table 2). An average of only 1.8571 leaf units of Julian were consumed compared to 36.1428 for line 61-15op-35. Despite the low average for Julian, it was not significantly different from the next 13 lowest lines and varieties.

The average number of leaf units eaten by first instar larvae of P. ornithogalli ranged from 3.1429 for line 66-38x23-1 to a high of 19.8571 for Hayman (Table 3). Only 4 lines and varieties--66-T5x23-1, Coastal Sweet, 66-Gop-7, and Hayman--were significantly different from 66-38x23-1 which was least preferred.

Table 2. Number of leaf units (0.01 sq in) of sweetpotato varieties consumed by <u>Prodenia eridania</u> (Cramer) first instar larvae in 48 hours in the laboratory (7 replicates)

Lines and varieties	Range	Average	Adjusted mean*
Julian	0-8	1.8571	-4.3609a
Johnson	0-22	5.4285	3.9033ab
Georgia Red	0-50	9.2857	5.5041ab
66-Gop-7	0-14	7.0000	5.6707ab
66-23op-3	0-24	8.0000	7.1768abc
65-ES-S3	0-22	6.4285	7.7589abc
0-T6x16op-13	0-28	9.4285	7.8108abc
61-15op-41	0-26	9.7142	8.2392abc
NC-246	0-17	8.5714	8.7409abc
66-38x23-1	0-24	10.2857	10.0912abc
64-Gx-102-1	0-19	7.2857	10.1571abc
64-2x23-71	0-21	10.2857	10.8235abc
66-T5x23-1	0-20	10.1428	11.1345abc
Rose Centennial	0-38	12.4285	11.6207abc
Coastal Sweet	0-42	13.2857	13.3757 bc
Hayman	0-35	13.4285	13.8516 bc
65-72xG-1	6-27	13.1428	14.0788 bc
63-T-3xE-3	0-37	18.2857	18.6655 bcd
65-2op-8	0-38	18.5714	19.9405 bcd
63-EXG-8	0-58	20.1428	20.1824 bcd
65-2x63-1	1-53	23.8571	23.1773 cde
308198	0-64	28.8571	31.2557 def
Muguga	0-65	35.1428	38.1644 ef
61-15op-35	18-53	36.1428	40.0360 f

* Any means followed by the same letter are not significantly different at the 5% level. Duncan's multiple range test

Table 3. Number of leaf units (0.01 sq in) of sweetpotato varieties consumed by _Prodenia ornithogalli_ Guenee first instar larvae in 48 hours in the laboratory (7 replicates)

Lines and varieties	Range	Average	Adjusted mean*
66-38x23-1	0-7	3.1429	1.2156a
61-15op-41	2-17	5.4286	3.7492ab
64-2x23-71	1-10	3.8571	3.9485ab
63-T-3xE-3	1-14	4.8571	3.9497ab
308198	1-8	5.2857	3.9941ab
63-ExG-8	0-9	4.0000	4.0716ab
66-23op-3	0-8	4.0000	5.1176ab
64-Gx-102-1	1-23	7.4286	5.4717ab
Georgia Red	0-19	5.1429	5.5649ab
65-2op-8	1-14	6.2857	6.5784ab
Johnson	3-15	7.7143	6.6481ab
NC-246	1-19	6.2857	6.7073ab
Julian	0-15	7.8571	6.8045ab
Muguga	0-19	7.2857	7.3548ab
65-72xG-1	0-48	9.5714	8.2116ab
0-T6x16op-13	0-18	7.8571	8.3664ab
65-ES-S3	1-16	7.7143	8.5521ab
65-2x63-1	4-16	7.8571	9.2440ab
61-15op-35	2-17	8.5714	9.3184ab
Rose Centennial	2-24	9.2857	9.6617ab
66-T5x23-1	0-28	10.0000	10.1960 b
Coastal Sweet	1-33	11.4286	12.3601 bc
66-GOP-7	1-25	16.4286	18.6581 cd
Hayman	8-38	19.8571	21.3980 d

* Any means followed by the same letter are not significantly different at the 5% level. Duncan's multiple range test

Table 4. Number of leaf units (0.01 sq in) of sweetpotato varieties consumed by Prodenia sunia (Guenee) first instar larvae in 48 hours in the laboratory (7 replicates)

Lines and varieties	Range	Average	Adjusted mean*
Hayman	0-8	4.0000	0.1925
63-T-3xE-3	0-10	3.7143	2.3530
Johnson	0-7	3.0000	2.6659
Julian	0-17	5.0000	4.1318
61-15op-41	0-25	8.5714	6.5733
64-Gx-102-1	0-27	10.2857	8.7490
Rose Centennial	2-19	10.2857	9.8262
NC-246	1-20	10.0000	10.1889
Georgia Red	0-25	12.1429	11.9025
66-23op-3	6-22	14.1429	12.4925
0-T6x16op-13	0-28	13.2857	12.5709
64-2x23-71	0-29	12.8571	12.7950
65-2op-8	0-51	14.4285	14.1853
66-Gop-7	4-27	14.2857	14.8718
Muguga	1-32	13.4286	15.1581
65-ES-S3	0-34	14.2857	15.6607
Coastal Sweet	0-27	14.7143	16.1834
61-15op-35	2-39	15.1429	16.2837
65-2x63-1	4-39	17.8571	17.9457
63-ExG-8	1-46	18.7143	20.0893
65-72xG-1	8-42	21.8571	22.4885
66-38x23-2	6-46	20.2857	23.2309
308198	0-47	22.0000	23.4217
66-T5x23-1	3-45	23.1429	23.4673

* No significant difference at the 5% level

Table 5. Number of leaf units (0.01 sq in) of sweetpotato varieties consumed by Prodenia dolichos (Fabricius) first instar larvae in 48 hours in the laboratory (7 replicates)

Lines and varieties	Range	Average	Adjusted mean*
66-23op-3	0-9	3.7142	1.5981
Muguga	0-14	5.4285	4.8349
66-38x23-1	0-11	5.0000	5.2512
65-2op-8	0-14	5.2857	5.3751
Georgia Red	1-8	5.1428	5.4622
Julian	0-20	7.2857	6.2386
63-ExG-8	0-15	7.8571	6.5840
Coastal Sweet	0-11	7.1428	6.7567
65-2x63-1	1-16	8.7142	6.9459
64-Gx-102-1	0-15	6.1428	6.9526
63-T-3xE-3	0-24	6.7142	7.0547
66-T5x23-1	0-13	6.4285	7.0887
0-T6x16op-13	0-31	8.4285	7.6518
61-15op-35	0-26	8.1428	8.0326
65-ES-S3	2-16	8.5714	9.1843
65-72xG-1	4-14	9.0000	9.3093
Johnson	1-12	9.1428	9.4699
Rose Centennial	1-23	9.7142	9.6251
NC-246	0-16	8.4285	9.7938
64-2x23-71	0-23	9.2857	10.0942
66-Gop-7	2-31	12.7142	11.4815
61-15op-41	1-21	11.7142	12.9354
Hayman	5-22	11.1428	13.2004
308198	3-21	12.7142	13.3638

* No significant difference at the 5% level

The range in the average number of leaf units consumed by P. sunia larvae was greater than that obtained for P. ornithogalli, but the differences were not significant (Table 4). The lowest average was for the variety Johnson, but Hayman and line 63-T-3xE-3 had lower adjusted means. The line with the most injury was 66-T5x23-1.

The least difference among varieties based on the average number of leaf units eaten was obtained for P. dolichos (Table 5). Of the low line 66-23op-3, 3.7142 leaf units were eaten compared to only 12.7142 for the highest line 308198.

The average number of leaf units of all lines and varieties consumed by the larvae ranged from 14.0416 for P. eridania, 13.2261 for P. sunia, down to 8.0773 for P. dolichos, and 7.7976 for P. ornithogalli. This would indicate that sweetpotato as a food plant was more acceptable to P. eridania and sunia than to the other 2 species.

Two sweetpotatoes, Georgia Red and 66-23op-3, were in the top 10 least eaten varieties for all Prodenia species and line 61-15op-35 was 1 of the top 11 lines and varieties most eaten.

The results of these tests show that various degrees of preference occurred among the Prodenia species, particularly eridania and ornithogalli for the 24 lines and varieties tested. This confirms the statement by Painter (1968) and Soo Hoo and Fraenkel (1966a) that "not all plants, not even different varieties within a species, are damaged or infested by insects to the same degree." Preference and non-preference were shown to exist in this case.

Physical and Chemical Leaf Component Test

First instar Prodenia ornithogalli larvae (48 hours old) were placed one at a time on the underside of either the most susceptible variety

(Hayman) or the most resistant line (66-38x23-1) leaves, and observed under the microscope for 5 minutes. Eight out of 10 larvae fed on leaves of the most susceptible variety but only 2 out of 10 larvae fed on the most resistant line.

Sweetpotato leaves of the most susceptible and the most resistant varieties and lines from the preference test to Prodenia ornithogalli and eridania were blended and incorporated in 2% agar disks. One petri dish contained 2 water agar disks and either 2 resistant or 2 susceptible agar disks. The results of the test indicate (Table 6) that there was no significant difference between the susceptible and resistant agar disks based on average number of first instar larvae per disk, of P. ornithogalli or eridania present on the disks after 1, 3, 6, and 12 hours. The highest average number (5.75) of P. eridania larvae per disk occurred on the susceptible variety disk after 12 hours, but for P. ornithogalli the susceptible variety had slightly less average numbers of larvae per disk throughout the test.

The test was repeated to determine whether larval feeding was due to preference after the physical properties of leaves were eliminated by the blending process. The procedure was exactly as above except that each dish contained 4 agar disks, 1 resistant, 1 susceptible, and 2 agar check disks. The results show (Table 7) that there was no significant difference between the susceptible and resistant agar disks based on average numbers of first instar larvae per disk of P. ornithogalli or eridania present after 1, 3, 6, and 12 hours.

From these tests (Tables 6 and 7) it can be concluded that following blending and incorporation into agar disks both the susceptible and resistant varieties are equally acceptable to first instar larvae of

Table 6. Average number of first instar larvae of *Prodenia ornithogalli* or *eridania* per disk in petri dishes each containing two water agar disks and either two resistant or two susceptible agar disks, after 1, 3, 6, and 12 hours. 1968

	Average no. of larvae per disk			
	Hr			
	1	3	6	12
P. ornithogalli				
Susceptible variety (Hayman)	1.50	3.00	3.50	3.25
vs Agar	0.25	0.25	0.25	0.00
Resistant variety (66-38x23-1)	1.75	3.25	4.75	4.25
vs Agar	0.00	0.50	0.25	0.50
P. eridania				
Susceptible variety (61-15op-35)	3.00	4.00	4.75	5.75
vs Agar	0.50	0.50	0.75	0.25
Resistant variety (Julian)	2.50	4.00	4.75	3.50
vs Agar	0.00	0.50	0.75	0.50

Table 7. Average number of first instar larvae of _Prodenia ornithogalli_ or _eridania_ per disk in petri dishes each containing two water agar disks plus one resistant and one susceptible agar disk, after 1, 3, 6, and 12 hours. 1968

	Average no. of larvae per disk			
	Hr			
	1	3	6	12
P. ornithogalli				
Susceptible variety (Hayman)	1.50	3.00	3.50	3.25
vs				
Agar	0.13	0.38	0.25	0.25
vs				
Resistant variety (66-38x23-1)	1.75	3.25	4.75	4.25
P. eridania				
Susceptible variety (61-15op-35)	0.75	0.75	1.00	2.75
vs				
Agar	0.38	0.25	0.00	0.13
vs				
Resistant variety (Julian)	2.00	1.50	2.00	2.25

P. eridania and ornithogalli. It appears that a physical factor was responsible for the failure of P. ornithogalli larvae to feed on the 66-38x23-1 leaves.

To determine the nature of the feeding stimulant, cold water, hot water and chloroform + methanol (2:1) leaf extracts were made. Sweet-potato leaves of the most susceptible and the most resistant lines and varieties from the preference test to P. ornithogalli and eridania were extracted. Extracts from cold and hot water were incorporated into 2% agar solution but solvent extract with chloroform + methanol was applied topically to a water agar disk and the solvent allowed to evaporate. One dish contained water, susceptible and resistant leaf extract in agar disks for each extract.

The results of the P. ornithogalli test show (Table 8) that the susceptible variety cold water agar disk had about 4 times more larvae than the resistant variety cold water agar disk after 1 hour, and after 3 hours, the susceptible agar disk had about 2 times more than the resistant agar disk. After 6 and 12 hours, there were no larvae present on the susceptible cold water agar disk and only a few were on the resistant cold water agar disk. There was little difference in numbers of larvae present between the susceptible hot water and the resistant hot water agar disks, or in the numbers of larvae present between the susceptible chloroform + methanol and the resistant chloroform + methanol agar disks after 1, 3, 6, and 12 hours. However, it was obvious that more larvae responded to the chloroform + methanol extract agar disks whether it was of a resistant or a susceptible variety. This indicated that a feeding stimulant might be present to a greater extent in the chloroform + methanol extract than in the other 2 extracts.

Table 8. Average number of first instar larvae of Prodenia ornithogalli or eridania per disk in petri dishes each containing water agar disk (check) as well as susceptible, and resistant agar disk made from cold water, hot water, and chloroform + methanol extract, after 1, 3, 6, and 12 hours. 1968

	Average no. of larvae per disk			
	Hr			
	1	3	6	12
P. ornithogalli				
Cold water extract				
Susceptible variety (Hayman)	3.33	0.67	0.00	0.00
vs				
Agar	0.00	0.00	0.50	0.33
vs				
Resistant variety (66-38x23-1)	0.83	0.33	0.83	0.50
Hot water extract				
Susceptible variety (Hayman)	0.50	0.00	0.33	0.00
vs				
Agar	0.00	0.00	0.50	0.00
vs				
Resistant variety (66-38x23-1)	0.83	0.17	0.50	0.00
Chloroform + methanol extract				
Susceptible variety (Hayman)	4.00	2.33	3.00	0.00
vs				
Agar	0.00	0.00	0.00	0.00
vs				
Resistant variety (66-38x23-1)	2.67	3.17	2.33	2.50
P. eridania				
Cold water extract				
Susceptible variety (61-15op-35)	0.17	0.33	0.83	0.33
vs				
Agar	0.00	0.00	0.00	0.17
vs				
Resistant variety (Julian)	0.00	0.00	0.00	0.50
Hot water extract				
Susceptible variety (61-15op-35)	0.00	0.17	0.17	0.00
vs				
Agar	0.33	0.17	0.00	0.17
vs				
Resistant variety (Julian)	0.00	0.00	0.50	1.17
Chloroform + methanol extract				
Susceptible variety (61-15op-35)	0.17	0.83	0.67	0.67
vs				
Agar	0.00	0.00	0.00	0.00
vs				
Resistant variety (Julian)	0.67	0.50	1.00	1.50

Only 5 first instar P. eridania larvae were used per replicate, instead of the 10 used in P. ornithogalli, due to the shortage of larvae during the test (Table 8). The susceptible cold water agar disk had more larvae present than the resistant cold water agar disk. Not until after 12 hours did any larvae appear at the resistant cold water disk. No difference in numbers of larvae present between susceptible and resistant agar disks in hot water extract existed. More P. eridania larvae responded to the chloroform + methanol extract disks than the other 2 extracts but the differences were not very great when compared to chloroform + methanol extract in P. ornithogalli.

Antibiosis Test

Twelve sweetpotato varieties were tested in 1967 to determine whether any difference in suitability for larval development existed. The Prodenia species tested were eridania, ornithogalli, sunia, and latifascia. Evaluation for antibiosis was based on the duration of larval-pupal stages, percent pupation, and pupal weights as shown in Tables 9, 10, 11, and 12. The duration of larval-pupal stages is arranged from low to high but the percent pupation and pupal weights are arranged from high to low. It is assumed that lines and varieties most favorable for larval development would result in the shortest larval-pupal development time and also that the percent pupation and the pupal weights would be highest on these varieties. Conversely, unfavorable lines or varieties might increase the duration of larval-pupal development time and lower the percent pupation and the pupal weights.

The highest percent pupation, ranging from 65 to 95%, and the shortest duration of larval-pupal stages, ranging from 27.24 to 31.77 days, were

Table 9. Pupal weight, percent pupation, and larval-pupal duration of *Prodenia eridania* (Cramer) reared on different lines and varieties of sweetpotato leaves in the laboratory. 1967

Lines and varieties	Duration (days) larval-pupal stages	Lines and varieties	% pupation	Lines and varieties	Ave. pupal wt (mg)
Gold Rush	27.24	Gem	95	Gold Rush	261.7
Centennial	27.33	Julian	95	Centennial	256.0
LO-246	28.29	NC 212	95	Gem	251.5
Unit #1 Porto Rico	28.33	Unit #1 Porto Rico	90	Unit #1 Porto Rico	251.4
PR 198	28.61	NC 172	90	PR 198	226.8
Georgia Red	28.82	Cuban	90	Georgia Red	226.2
Gem	29.12	LO-246	85	LO-246	225.7
NC 172	29.56	Gold Rush	85	Julian	225.7
Cuban	31.00	Rose Centennial	85	Cuban	220.6
NC 212	31.06	Centennial	80	NC 172	219.5
Julian	31.32	Georgia Red	65	NC 212	218.4
Rose Centennial	31.77	PR 198	65	Rose Centennial	208.5
Artificial Diet	27.22	Artificial Diet	90	Artificial Diet	336.6

Table 10. Pupal weight, percent pupation, and larval-pupal duration of *Prodenia ornithogalli* Guenee reared on different lines and varieties of sweetpotato leaves in the laboratory. 1967

Lines and varieties	Duration (days) larval-pupal stages	Lines and varieties	% pupation	Lines and varieties	Ave. pupal wt (mg)
Unit #1 Porto Rico	31.60	NC 172	55	Unit #1 Porto Rico	309.4
NC 212	32.25	Unit #1 Porto Rico	50	Gold Rush	295.8
Gold Rush	32.40	Centennial	45	Centennial	288.3
LO-246	32.63	LO-246	40	NC 172	255.4
Gem	33.47	Rose Centennial	40	Gem	252.5
NC 172	33.82	Julian	40	PR 198	248.0
Centennial	34.00	Gem	35	Rose Centennial	246.0
Georgia Red	34.17	Georgia Red	30	NC 212	234.7
PR 198	34.50	PR 198	30	LO-246	233.1
Rose Centennial	34.76	Cuban	30	Georgia Red	216.2
Cuban	36.17	Gold Rush	25	Cuban	195.2
Julian	36.22	NC 212	20	Julian	192.6
Artificial Diet	32.99	Artificial Diet	45	Artificial Diet	343.2

Table 11. Pupal weight, percent pupation, and larval-pupal duration or *Prodenia sunia* (Guenee) reared on different lines and varieties of sweetpotato leaves in the laboratory. 1967

Lines and varieties	Duration (days) larval-pupal stages	Lines and varieties	% pupation	Lines and varieties	Ave. pupal wt (mg)
LO-246	29.70	PR 198	50	LO-246	219.2
Centennial	29.87	Centennial	40	NC 172	204.8
Gem	30.16	NC 212	40	Centennial	192.8
Cuban	30.40	Rose Centennial	40	Julian	190.4
NC 172	30.50	LO-246	35	NC 212	187.7
Unit #1 Porto Rico	30.60	Georgia Red	35	Georgia Red	184.6
Rose Centennial	30.87	Gold Rush	30	Rose Centennial	178.7
NC 212	31.29	Julian	30	Cuban	176.9
PR 198	33.10	NC 172	25	PR 198	170.9
Georgia Red	33.42	Unit #1 Porto Rico	25	Gold Rush	168.4
Gold Rush	33.66	Cuban	25	Gem	168.1
Julian	34.16	Gem	15	Unit #1 Porto Rico	159.5
Artificial Diet	35.17	Artificial Diet	30	Artificial Diet	204.5

Table 12. Pupal weight, percent pupation, and larval-pupal duration of *Prodenia latifascia* Walker reared on different lines and varieties of sweetpotato leaves in the laboratory. 1967

Lines and varieties	Duration (days) larval-pupal stages	Lines and varieties	% pupation	Lines and varieties	Ave. pupal wt (mg)
Centennial	30.60	NC 172	35	Centennial	585.4
NC 212	31.00	LO-246	35	PR 198	578.2
NC 172	31.38	Unit #1 Porto Rico	35	Gem	543.8
Gold Rush	31.50	PR 198	30	Rose Centennial	518.1
Cuban	31.84	Gold Rush	30	LO-246	500.3
Julian	32.75	Rose Centennial	30	Julian	498.8
Rose Centennial	32.84	Cuban	30	Gold Rush	491.1
Unit #1 Porto Rico	33.15	Georgia Red	30	NC 172	487.3
Gem	33.20	Centennial	25	NC 212	478.6
LO-246	34.43	Gem	25	Georgia Red	475.8
PR 198	34.83	Julian	20	Unit #1 Porto Rico	468.8
Georgia Red	35.34	NC 212	20	Cuban	443.9
Artificial Diet	35.44	Artificial Diet	45	Artificial Diet	599.9

obtained with *P. eridania* (Table 9). This indicates that sweetpotato as a host plant was more acceptable to *P. eridania* than to the other 3 species. For the most favorable variety, Gold Rush, larval-pupal development took 27.24 days and average pupal weight was 261.7 mg as compared to 31.77 days and 208.5 mg for the least favorable variety, Rose Centennial.

For *P. ornithogalli* the percent pupation ranged from 20 to 55% (Table 10). The most favorable variety was Unit #1 Porto Rico, with larval-pupal development taking 31.60 days and an average pupal weight of 309.4 mg while larval and pupal development took 36.22 days and average pupal weight was 192.6 mg for the least favorable variety, Julian.

The percent pupation of *P. sunia* ranged from 15 to 50% (Table 11). Based on duration of larval-pupal stages, the most favorable variety was LO-246. An average of 29.70 days was required on this line compared to 34.16 days on the least favorable variety, Julian. On the basis of pupal weight, LO-246 was again most favorable, producing pupae weighing an average of 219.2 mg compared to 159.5 mg for the least favorable variety, Unit #1 Porto Rico.

The lowest percent pupation, ranging from 20 to 35%, was observed with *P. latifascia* (Table 12). This would indicate that sweetpotato as a food plant was less acceptable to *P. latifascia* than to the other 3 species. Centennial was the most favorable variety, based on both larval-pupal duration (30.60 days) and average pupal weight (585.4 mg). The least favorable variety based on larval-pupal duration (35.34 days) was Georgia Red but based on average pupal weight (443.9 mg) Cuban was least favorable. While the average pupal weight of *P. latifascia* ranged from

443.9 mg to 585.4 mg which is much higher than for the other 3 species, this does not indicate that sweetpotato is a better food for P. latifascia since it is the largest of the 4 Prodenia species tested.

In 1968, 24 varieties and lines of sweetpotato were evaluated in similar tests. The Prodenia species tested in 1968 were eridania, ornithogalli, sunia and dolichos. The results of these tests are presented in Tables 13, 14, 15, and 16.

The most favorable line for P. eridania was 66-23op-3 based on both larval-pupal duration (31.58 days) and average pupal weight (285.7 mg) (Table 13). The least favorable line based on average pupal weight was 66-Gop-7 (203.1 mg) and based on larval-pupal duration it was Georgia Red (37.68 days).

For P. ornithogalli, the most favorable variety for larval-pupal development was 66-23op-3 (29.81 days) and the least favorable was Coastal Sweet (40.70 days)(Table 14). On the basis of average pupal weight, the most favorable and least favorable were Hayman (358.8 mg) and 63-T-3xE-3 (226.8 mg), respectively.

The results obtained with P. sunia are shown in Table 15. The most favorable lines based on larval-pupal duration and average pupal weight were 64-Gx-102-1 (30.29 days) and 66-26op-5 (220.3 mg) compared to the least favorable line 63-T-3xE-3 (40.82 days and 185.7 mg).

For P. dolichos, the most favorable line based on larval-pupal duration was 64-Gx-102-1 (38.79 days) and the least favorable was line 61-15op-35 (46.78 days). The most favorable and least favorable lines based on average pupal weight were 65-2x63-1 and 61-15op-35 (615.3 mg and 401.7 mg), respectively (Table 16).

Table 13. Pupal weight, percent pupation, and larval-pupal duration of *Prodenia eridania* (Cramer) reared on different lines and varieties of sweetpotato leaves in the laboratory. 1968

Lines and varieties	Duration (days) larval-pupal stages	Lines and varieties	% pupation	Lines and varieties	Ave. pupal wt (mg)
66-23op-3	31.58	64-Gx-102-1	75	66-23op-3	285.7
66-T5x23-1	32.17	61-15op-35	75	66-38x23-2	280.4
308198	32.23	66-T5x23-1	75	64-10op-4	275.2
66-26op-5	32.29	308198	75	64-Gx-102-1	274.8
Johnson	32.42	Hayman	70	308198	268.7
Hayman	32.67	66-26op-5	70	65-72xG-1	267.0
61-15op-35	32.77	65-2x63-1	65	0-T6x16op-13	265.4
65-2op-8	33.00	Muguga	65	Johnson	264.0
66-38x23-2	33.08	66-38x23-2	60	66-T5x23-1	260.9
64-Gx-102-1	33.11	64-2x23-71	60	Hayman	252.7
61-15op-41	33.28	Johnson	60	Coastal Sweet	247.8
65-72xG-1	33.56	66-23op-3	60	Muguga	247.4
NC-246	33.71	65-ES-S3	55	61-15op-41	243.5
64-10op-4	33.94	Coastal Sweet	55	64-2x23-71	242.6
Coastal Sweet	33.98	65-2op-8	50	65-2op-8	238.6
0-T6x16op-13	34.44	65-72xG-1	50	65-ES-S3	236.7
66-Gop-7	34.83	63-ExG-8	50	61-15op-35	236.5
Muguga	35.15	61-15op-41	50	66-26op-5	231.7
65-2x63-1	35.46	64-10op-4	45	NC-246	227.4
63-T-3xE-3	35.60	0-T6x16op-13	45	65-2x63-1	224.2
65-ES-S3	35.75	63-T-3xE-3	40	63-T-3xE-3	220.6
64-2x23-71	35.75	Georgia Red	40	Georgia Red	218.8
63-ExG-8	36.75	66-Gop-7	40	63-ExG-8	214.2
Georgia Red	37.68	NC-246	35	66-Gop-7	203.1
Artificial Diet	52.29	Artificial Diet	30	Artificial Diet	224.1

Table 14. Pupal weight, percent pupation, and larval-pupal duration of *Prodenia ornithogalli* Guenee reared on different lines and varieties of sweetpotato leaves in the laboratory. 1968

Lines and varieties	Duration (days) larval-pupal stages	Lines and varieties	% pupation	Lines and varieties	Ave.pupal wt (mg)
66-23op-3	29.81	64-2x23-71	65	Hayman	358.8
Hayman	31.78	Georgia Red	65	Coastal Sweet	335.6
66-38x23-2	34.36	66-Gop-7	65	Muguga	326.8
65-72xG-1	34.54	61-15op-41	65	0-T6x16op-13	321.6
0-T6x16op-13	34.84	Muguga	65	61-15op-41	319.5
65-2x63-1	35.45	61-15op-35	60	66-23op-3	312.2
Muguga	35.63	66-T5x23-1	60	308198	308.2
66-T5x23-1	36.38	308198	60	65-2x63-1	299.4
61-15op-41	36.63	63-T-3xE-3	55	66-38x23-2	298.0
64-Gx-102-1	37.33	63-ExG-8	50	66-26op-5	293.4
308198	37.57	Hayman	50	66-Gop-7	290.2
64-10op-4	37.69	66-26op-5	50	64-10op-4	287.3
61-15op-35	38.08	64-10op-4	50	65-72xG-1	287.1
65-2op-8	38.11	0-T6x16op-13	50	66-T5x23-1	280.8
Georgia Red	38.54	64-Gx-102-1	45	Georgia Red	278.9
66-26op-5	38.48	62-2op-8	45	61-15op-35	277.5
63-T-3xE-3	39.28	NC-246	45	64-Gx-102-1	274.5
NC-246	39.33	66-38x23-2	40	64-2x23-71	266.9
Johnson	39.63	65-ES-S3	40	NC-246	257.2
64-2x23-71	39.66	Johnson	40	65-2op-8	253.5
66-Gop-7	40.25	66-23op-3	40	65-ES-S3	249.2
63-ExG-8	40.47	65-2x63-1	40	63-ExG-8	238.3
65-ES-S3	40.55	65-72xG-1	35	Johnson	231.5
Coastal Sweet	40.70	Coastal Sweet	30	63-T-3xE-3	226.8
Artificial Diet	44.10	Artificial Diet	50	Artificial Diet	311.1

Table 15. Pupal weight, percent pupation, and larval-pupal duration of <u>Prodenia sunia</u> (Guenee) reared on different lines and varieties of sweetpotato leaves in the laboratory. 1968

Lines and varieties	Duration (days) larval-pupal stages	Lines and varieties	% pupation	Lines and varieties	Ave. pupal wt (mg)
64-Gx-102-1	30.29	65-72xG-1	80	66-26op-5	220.3
66-Gop-7	30.33	64-Gx-102-1	75	0-T6x16op-13	216.6
61-15op-41	31.63	63-T-3xE-3	70	66-Gop-7	214.9
66-23op-3	32.26	Johnson	70	64-Gx-102-1	214.8
Muguga	32.38	66-23op-3	70	66-23op-3	214.0
0-T6x16op-13	32.73	61-15op-35	65	64-10op-4	209.4
Coastal Sweet	32.81	66-T5x23-1	65	Johnson	209.0
Hayman	32.93	65-2x63-1	65	NC-246	208.2
65-2op-8	33.16	Muguga	65	308198	207.3
61-15op-35	33.30	Georgia Red	60	61-15op-41	206.2
308198	33.65	308198	60	65-ES-S3	205.3
66-38x23-2	33.70	65-2op-8	55	Hayman	204.1
64-10op-4	33.80	0-T6x16op-13	55	Coastal Sweet	203.2
65-72xG-1	34.00	Hayman	50	65-72xG-1	202.2
65-ES-S3	34.00	64-2x23-71	50	Muguga	198.5
NC-246	34.39	66-38x23-2	45	61-15op-35	198.3
65-2x63-1	34.52	NC-246	45	66-38x23-2	198.1
66-T5x23-1	34.98	66-26op-5	45	66-T5x23-1	198.0
64-2x23-71	35.23	Coastal Sweet	45	65-2x63-1	197.3
Johnson	35.72	63-ExG-8	40	64-2x23-71	197.3
63-ExG-8	36.53	61-15op-41	40	65-2op-8	192.0
Georgia Red	36.61	64-10op-4	40	Georgia Red	190.3
66-26op-5	36.94	66-Gop-7	30	63-ExG-8	186.6
63-T-3xE-3	40.82	65-ES-S3	20	63-T-3xE-3	185.7
Artificial Diet	42.25	Artificial Diet	20	Artificial Diet	217.2

Table 16. Pupal weight, percent pupation, and larval-pupal duration of Prodenia dolichos (Fabricius) reared on different lines and varieties of sweetpotato leaves in the laboratory. 1968

Lines and varieties	Duration (days) larval-pupal stages	Lines and varieties	% pupation	Lines and varieties	Ave. pupal wt (mg)
64-Gx-102-1	38.79	0-T6x16op-13	60	65-2x63-1	615.3
66-38x23-2	39.25	64-10op-4	50	Coastal Sweet	595.8
66-T5x23-1	39.86	Hayman	45	308198	587.1
Johnson	40.64	61-15op-41	45	NC-246	582.6
308198	41.23	65-72xG-1	45	66-23op-3	548.5
65-2x63-1	41.30	64-2x23-71	40	66-T5x23-1	545.4
64-10op-4	41.48	61-15op-35	40	65-ES-S3	535.1
NC-246	42.00	Georgia Red	35	66-38x23-2	535.0
64-2x23-71	42.25	66-T5x23-1	35	64-2x23-71	534.6
63-T-3xE-3	42.50	64-Gx-102-1	35	65-2op-8	533.0
Coastal Sweet	43.05	308198	30	61-15op-41	529.4
66-26op-5	43.17	Muguga	30	64-Gx-102-1	527.5
65-2op-8	43.84	66-26op-5	30	66-26op-5	527.1
65-72xG-1	43.89	63ExG-8	30	63-ExG-8	521.3
65-ES-S3	44.23	63-T-3xE-3	30	Johnson	517.5
61-15op-41	44.44	NC-246	30	Hayman	506.2
Hayman	44.50	65-2op-8	30	Muguga	482.2
Georgia Red	44.53	65.ES-S3	30	66-Gop-7	480.9
63-ExG-8	44.83	66-38x23-2	30	65-72xG-1	479.6
Muguga	45.40	65-2x63-1	25	63-T-3xE-3	469.4
66-Gop-7	45.67	Coastal Sweet	25	64-10op-4	464.9
0-T6x16op-13	45.83	Johnson	25	Georgia Red	439.0
66-23op-3	46.00	66-Gop-7	15	0-T6x16op-13	430.9
61-15op-35	46.78	66-23op-3	15	61-15op-35	401.7
Artificial Diet	46.50	Artificial Diet	40	Artificial Diet	616.4

The percent pupation varied much more than either larval-pupal duration or pupal weight. The range and average percent pupation for each species was 35-75 (ave. 56.88) for P. eridania, 30-65 (ave. 49.17) for P. ornithogalli, 20-80 (ave. 54.38) for P. sunia, and 15-60 (ave. 33.54) for P. dolichos. These percentages are higher than those obtained in 1967 except for P. eridania.

The variation in larval-pupal duration obtained in 1967 when mostly commercial varieties were tested was very consistent, ranging 4.5 days for P. sunia to 4.7 days for P. latifascia. In 1968, when many breeding lines representing diverse genetic lines were included in the test, the variation was much greater, ranging from 6.1 days for P. eridania to 10.9 days for P. ornithogalli.

Variations in pupal weight were greatest for P. ornithogalli, and dolichos. The lightest pupae weighed only 62-65% as much as the heaviest pupae. For the other species, the lightest pupae weighed from 71-84% as much as the heaviest pupae.

It is apparent that larval development is affected by the various sweetpotato lines and varieties as indicated by the duration of the larval-pupal stages, the pupal weight, and the percent pupation. If larval-pupal development took as much as 10 days more on some varieties than on others, as shown for both P. ornithogalli and sunia in 1968, it might mean that fewer generations would be produced each year. Furthermore, the low survival rates on some varieties and lines would decrease the number of adults produced by each generation. Lower pupal weights mean lower fecundity of the female moths, which would also tend to reduce population. Additional work is needed to determine whether similar results could be obtained under other conditions.

SUMMARY

Five species of _Prodenia_ were reared in the laboratory. A slightly modified Shorey and Hale pinto bean medium was utilized for rearing the _Prodenia_ larvae. Most of the larvae used in the tests were from laboratory colonies.

In 1968, 24 lines and varieties of sweetpotato were tested to determine whether first instar larvae of _Prodenia eridania_, _ornithogalli_, _sunia_, and _dolichos_ would prefer 1 line or variety over another. The evaluation for preference was based on the number of leaf units consumed by each species in 48 hours. Significant differences in preference were obtained for _P. eridania_ and _ornithogalli_ but not for _P. sunia_ and _dolichos_. The lowest average number of leaf units consumed by _P. eridania_ was 1.8571 for Julian and the highest was 36.1428 for line 61-15op-35. The average number of leaf units consumed by _P. ornithogalli_ ranged from 3.1429 for line 66-38x23-1 to 19.8571 for Hayman. Sweetpotato as a food plant was acceptable to _P. eridania_ and _sunia_ based on the average number of leaf units consumed by the larvae. It is concluded that various degrees of preference existed among the _Prodenia_ species, particularly _eridania_ and _ornithogalli_, for the 24 lines and varieties tested.

Twelve varieties of sweetpotato were tested in 1967 and 24 varieties and breeding lines in 1968 to determine their suitability for larval development. The species of _Prodenia_ tested both years were _eridania_, _ornithogalli_, and _sunia_. Also, _P. latifascia_ was tested in 1967, and _P. dolichos_ in 1968. The evaluation for antibiosis was based on percent pupation, duration of larval-pupal stages, and pupal weight.

The percent pupation varied much more than either larval-pupal duration or pupal weight. The variation in larval-pupal duration was low in 1967 ranging from 4.5 to 4.7 days but in 1968 it ranged from 6.1 to 10.9 days, indicating that the variety or line could affect development. Pupal weight did not vary as much as percent pupation and larval-pupal duration.

First instar larvae of both *P. ornithogalli* and *eridania* were not attracted more to agar disks made from preferred varieties than non-preferred varieties. Agar disks made from cold water, hot water, and chloroform + methanol extracts of preferred and non-preferred varieties showed no differences in attractiveness to larvae of *P. ornithogalli* and *eridania*.

It is concluded that larval development was affected by the various sweetpotato lines and varieties as indicated by the duration of the larval-pupal stages, the pupal weight, and the percent pupation. If larval-pupal development took 10 days more on some lines or varieties than on others, it might mean that fewer generations would be produced each year. Lower survival rates as indicated by the percent pupation on some lines or varieties would decrease number of adults produced by each generation. Lower pupal weights would be responsible for lower fecundity of the female moths, which would reduce populations.

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BIOGRAPHICAL SKETCH

Kovit Kovitvadhi was born March 4, 1932, in Bangkok, Thailand. In March 1951, he graduated from Chulalongkorn University High School. In June 1956, he received the Bachelor of Science degree with a major in Agronomy from Kasetsart University. From 1956 until 1960 he was an official in the Pest and Disease Control Section, Extension Division, Rice Department, Ministry of Agriculture. He was responsible for demonstrating pest control techniques and conducting research on life histories and control of important rice pests. In 1960, he was sponsored by the International Cooperation Administration (U.S.O.M. to Thailand) as a graduate student in the Department of Entomology and Zoology, Clemson University, South Carolina, and received the degree of Master of Science with a major in Entomology in 1961. During his graduate work he received training on detection and control of diseases and insect pests of tropical crops, especially rice, at the Rice Experiment Station, Louisiana State University. From 1961 until 1965 he worked as Acting Chief of the Entomology Branch, Technical Division, Rice Department, in charge of research projects on rice insect control both in the field and in storage. He also served as an instructor of courses in Stored Product Entomology, and Insects of Rice and Other Cereal Crops, and academic advisor in the Department of Entomology and Plant Pathology, Kasetsart University. In 1962 he attended, through the sponsorship of the Colombo Plan, a course on the Principles and Methods of Crop Protection at Chesterford Park

Research Station, Fisons Pest Control Limited, and a course on the Control of Rodents and Technology of Control of Insect Pests of Stored Products at the Infestation Control Laboratory in England. In August 1965 he was awarded a fellowship for study leading to the degree of Doctor of Philosophy with a major in Entomology in the Graduate School of the University of Florida.

He is a member of the Entomological Society of America, Kasetsart University Alumni Association, Clemson University Alumni Association, American University Alumni Association of Thailand, and the Florida Entomological Society. He has participated in several national and international meetings, conferences, and symposiums on rice insect problems, and published more than 14 articles in Thai or English on rice insect pests.

Kovit Kovitvadhi married the former Kittima Somboon in 1956. They have two daughters and one son: Ariya, Chanida, and Satit.

This dissertation was prepared under the direction of the chairman of the candidate's supervisory committee and has been approved by all members of that committee. It was submitted to the Dean of the College of Agriculture and to the Graduate Council, and was approved as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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